Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 130 (2018) 239–246

Procedia Computer Science

www.elsevier.com/locate/procedia

9th International Conference on Ambient Systems, Networks and Technologies, ANT-2018 and the 8th International Conference on Sustainable Energy Information Technology, SEIT 2018, 8-11 May, 2018, Porto, Portugal

Promoting Knowledge Construction: A Model for Using Virtual Reality Interaction to Enhance Learning

Yun Zhou[a,*], Shangpeng Ji[a], Tao Xu[b,c], Zi Wang[a]

[a]School of Education, Shaanxi Normal University, Xi'an, 710062, P.R.China
[b]School of Software and Microelectronics, Northwestern Polytechnical University, Xi'an, 710072, P.R.China
[c]State Key Laboratory for Manufacturing Systems Engineering, Xi'an Jiaotong University, Xi'an Shaanxi, 710054, P.R.China

Abstract

VR technologies, offering powerful immersion and rich interaction, have gained great interest from researchers and practitioners in the field of education. However, current learning theories and models either mainly take into account the technology perspectives, or focus more on the pedagogy. In this paper, we propose a learning model benefiting from both the Human-Computer Interaction aspects and pedagogical aspects. This model takes full account of the impact of different factors including pedagogical contexts, VR roles and scenarios, and output specifications, which would be combined to inform the design and realize VR education applications. Based on this model, we design and implement an educational application of computer assembly under virtual reality using HTC Vive, which is a headset providing immersion experience. To analyze users' learning behaviors and evaluate their performance and experience, we conduct an evaluation with 32 college students as participants. We design a questionnaire including usability tests and emotion state measures. Results showed that our proposed learning model gave a good guidance for informing the design and use of VR-supported learning application. The use of the natural interaction not only makes the learning interesting and fosters the engagement, but also improves the construction of knowledge in practices.

Peer-review under responsibility of the Conference Program Chairs.

Keywords: Virtual Reality; Knowledge Construction; Evaluation; Learning Experience; Learning Model

1. Introduction

In recent years, Virtual Reality (VR) breaks through in different domains such as visual performance technology, tracking and positioning technology and interactive technology, which achieves a full range of immersion and interaction. These new VR technologies, which provide powerful immersion and rich interaction, have gained great interest from researchers and practitioners in the field of education [1 2]. However, the design and implantation of VR supported learning is common based on the technical perspectives but lack of well-defined learning theories and custom-designed models as the foundation and guidelines [3]. To provide learners with a natural interaction experience

* Corresponding author. Tel.: +86 29 85308047 ; fax: +86 29 85308047.
E-mail address: zhouyun@snnu.edu.cn

1877-0509
Peer-review under responsibility of the Conference Program Chairs.
10.1016/j.procs.2018.04.035

and at the same time support learning using VR technologies rationally, we propose a learning model considering both the pedagogy and the technical affordance of VR. Then we use this learning model to design and implement an educational application of computer assembly with two sessions, including the learning session and the game session. Concerning the VR device, we employ HTC Vive headset to offer the visual feedback and provide a profound immersive experience for learners. The learning session could be used to assist students to construct knowledge and explore in the virtual situations using controllers. The interactive game fosters the computer assembly learning. To analyze users' learning behaviors and evaluate their performance and experience, we conduct an evaluation with 32 college students as participants. We design a questionnaire including usability tests and emotion state measures, the usability questions are based on Technology Acceptance Model (TAM)[4], and the learning experience and emotion state parts are based on Game Experience Questionnaire (GEQ)[5]. Results showed that: 1) the proposed VR learning of computer assembly provided a good usability and learning experience for users. 2) There was no difference on performance between reality learners and VR learners, namely, VR learners learned as well as reality learners. 3) The challenge and the task completion time showed a signicant positive correlation.

2. Related Work

In this section, we briefly summarize the applications based on VR technology. Also, we discuss the learning theories and models underlie the VR learning applications.

The applications based on VR technology have been studied for many years, although it will take a long way to bring VR into the conventional class or the smart classroom. We categorize VR education applications into four types considering immersion levels that VR generates: desktop semi-immersive VR, mobile semi-immersive VR/Augmented Reality (AR), fully immersive VR room, and fully immersive headset supported VR. In the scenarios of desktop semi-immersive VR applications, desktop computers or pads are enhanced with graphic accelerating powers with two-dimensional screen delivering three-dimensional graphic performance. For example, Hwang and Hu[6] studied the peer learning behaviors using a collaborative virtual reality learning environment, which was proposed to facilitate three-dimensional geometric problem solving. In this work, a white board and virtual manipulates were integrated into virtual mathematics classroom. Learners could use desktop computer or pads to enter into this VR environment, and they explore and learn about geometry with VR technology. Mobile semi-immersive VR/AR learning refers to mobile devices supporting VR/AR representation. It is common to use mobile phone, tablet or pad to present and render virtual objects and 3D scenes, or augment objects on reality. In this scenario, users immerse in the virtual environment at a certain degree. For example, Arloon Plants[7], one of Arloon's apps, let young learners interact with and learn about plant ecosystems on mobile phone or tablet 3D via virtual scenes implemented by Unity 3D. Learners select a category and see 3D labeled pictures, short animations, and augmented-reality images. Fully immersive VR room has a deep immersion level, where the virtual scenes and objects are projected on the walls and the floor, surrounding user's view of 360 degree. VR technology stimulates the scenes in the real world and let users fully immerse and interact with virtual objects. Although some applications like Virtual Campus[8] support users to engage in VR environment at first person point of view and using Avatar, these applications employ desktop computers or pads as the physical devices to render 3D images. Current physical device and technology supporting full immersion are either the configuration like[9], or VR headset. VR headset like HTC Vive[10] provides room-scale virtual reality and 360 degree coverage immersion experience. In recent years, VR headset supported applications have been carrying forward market and the VR game app stores have emerged like STEAM VR[11]. Many VR education applications are developed like The Body VR: Journey Inside a Cell[12]. The Body VR: Journey Inside a Cell is an educational virtual reality experience that takes the user inside the human body. Travel through the bloodstream and discover how blood cells work to spread oxygen throughout the body.

Besides, from the perspective of VR roles in education, we classify the roles into two types: VR as an instructing tool in teaching and VR as the learning environment. VR technology is considered to be suitable to support multi-user interaction and collaboration. For example, the students participate in the conventional class and conduct group discussion and learning through apps like Arloon Plants[7] and its other apps. VR as the learning environment is common for users' self-directed learning. The scenes and objects in VR are designed to meet the learning objectives and focus on a specific topic. In this role, the VR application is similar to micro courses or lecture videos in MOOC but with high interactivity and immersion.